THE WARBLER

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ISSUE 8

OCTOBER 19, 2021

Dear Scientist, Thinker, Creator,

When we think of life, we often think of plants and animals, but **microscopic life** is much more prevalent on the Earth than larger organisms. It lives inside us, and it provides digestive and immune function. It resides in places no other organisms can, such as hot springs, deep sea vents, and even clouds. It persists without oxygen, something that all other life needs to survive. There have been studies on the ways in which bacteria within the gut drastically affect all our processes down to our emotions. Bacteria are fundamental parts of our ecosystems even though we can't perceive them. In fact, they are so small that we can't even fathom how small they are. If we didn't have bacteria, we wouldn't even be alive.

I remember my first time looking under a microscope, seeing an organism called *spirulina* being eaten by another small organism called *paramecium*. Seeing life that small functioning in the same ways that we do with other life forms was one of the most beautiful things I have seen in my entire life. There is so much happening in our world that we are not even aware of. We only know about one thousandth of all bacteria species in the world. Seeing that brought me a lot of perspective as I got older. It reminded me to always be curious and open to all possibilities.

Some organisms actually need to live in mutualistic relationships to survive. Organisms such as lichens wouldn't be here if they didn't have each other (lichens are organisms that are comprised of algae, a microorganism, with a fungus). The cooperative nature of life is something that I love to keep in mind whenever I'm working with others, and thinking about that when I get upset helps me stay grounded. People say that you can learn a lot from nature, and I think that microscopic life is no exception.

We hope you enjoy this week's edition of *The Warbler* as you explore nature under a microscope.

Taylor and the APAEP Team

"Biology will relate every human gene to the genes of other animals and bacteria, to this great chain of being." **WALTER GILBERT** // American biochemist

WORDS INSIDE

FOUND INSIDE "THE HISTORY OF PASTEURIZATION"
sterilization | the rendering of something free from viable microorganisms

arc | a curved path; a continuous progression or line of development

FOUND INSIDE "BACTERIA AT HYDROTHERMAL VENTS"
thermophile | of, relating to, or being an organism living at a high temperature

FOUND INSIDE "THIS WEIRDLY, SMART ..."
fractal | any of various extremely irregular curves or shapes for which any suitably chosen part is similar in shape to a given larger or smaller part when magnified or reduced to the same size

peculiar | different from the usual or normal

anthropocentric | considering human beings as the most significant entity of the universe

BIOHISTORY

Ask a Biologist | Cells Living in Cells

BY SALLY WARRING | Arizona State University | Accessed October 2, 2021

It's good to be friendly with your neighbors, right? Cooperation isn't just important for humans.

The earliest living neighbors on our planet were all single-celled creatures. Some of the neighboring single-cells joined and began living together as one organism, one inside the other. This partnership was so successful that it led to the evolution of many of the life forms on our planet, including humans.

What is a Cell?

All living things are made up of cells. Even though there are many millions of life forms on earth, all of them are made up of only two basic types of cell: prokaryotes and eukaryotes.

Cells contain DNA. Prokaryotes (pro-carry-oats) are small and simple and have rings of circular DNA floating free inside the cell. Eukaryotes (you-carry-oats) are large and more complex. They have a nucleus, which holds strings of linear DNA within a lipid membrane. All the life forms that you are used to seeing — animals (including humans), plants, and fungi — are made up of eukaryotic cells. The bacteria, which are too small to see without a microscope, are made up of prokaryotic cells.

Prokaryotic cells were some of the earliest life forms on earth. They first appear in the fossil record around 4 billion years ago. Prokaryotes were around for a long, long time before eukaryotic cells appeared around 1.8 billion years ago. This has led us to think that the ancestor of all eukaryotic cells was a prokaryote.

But to get from a prokaryote to a eukaryote, the cell needed to become a lot more complicated. Eukaryotic cells are powered by special organelles, which work a bit like batteries. All eukaryotes have an organelle called the mitochondrion which is the powerhouse of the cell, while plant cells have plastids which absorb sunlight to produce sugar.

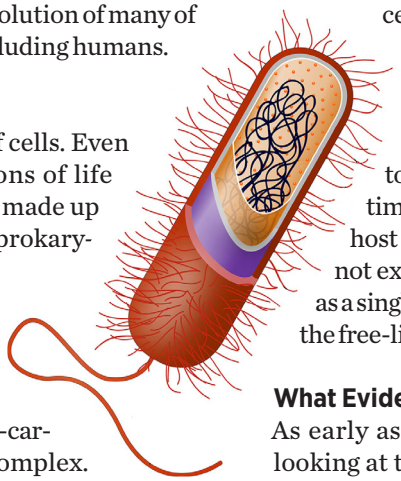
What is Endosymbiotic Theory?

How did the eukaryotes become so complicated? And where did these battery-like organelles come from?

We think we know part of the answer. Eukaryotic cells may have evolved when multiple cells joined together into one. They began to live in what we call symbiotic relationships. The theory that explains how this could have happened is called *endosymbiotic theory*. All eukaryotic cells, like your own, are creatures that are made up of the parts of other creatures.

The mitochondrion and the chloroplast are both organelles that were once free-living cells. They were prokaryotes that ended up inside of other cells (host cells). They may have joined the other cell by being eaten, or perhaps they were parasites of that host cell.

Rather than being digested by or killing the host cell, the inner cell survived and together they thrived. This happened a long time ago, and over time the organelle and the host cell have evolved together. Now one could not exist without the other. Today they function as a single organism, but we can still find evidence of the free-living past of the organelles if we look closely.



Prokaryotic cells are different than eukaryotic cells in that they don't have a nucleus (instead you can see the DNA material spread throughout the cell) and they are missing most of the organelles present in eukaryotic cells.

Images by Ali Zifan.

What Evidence Supports Endosymbiotic Theory?

As early as 1883, botanist Andreas Schimper was looking at the plastid organelles of plant cells using a microscope. He watched the plastids divide and noticed something odd. The process looked very similar to the way some free-living bacteria divided.

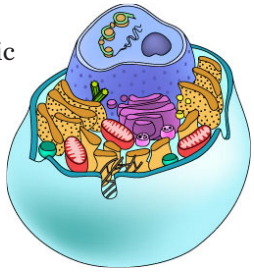
During the 1950s and 60s, scientists found that both mitochondria and plastids inside plant cells had different DNA from the rest of the plant cell. When scientists looked closer at the genes in the mitochondrial and plastid DNA, they found that the organelles were more like prokaryotes.

The green chloroplasts in this cell are now a critical part of plant cells, but they evolved from an entirely different organism than the plant cell.

So, organelles have their own DNA, and their genes are very similar to the genes of modern-day prokaryotes. Each eukaryote cell has to inherit at least one copy of an organelle from its parent cell if it is to live. That means that the genetic information needed to make the organelles is not found in the DNA of the eukaryotic cell. We think this evidence tells us that organelles were once free-living prokaryotes.

But our story of the evolution of eukaryotic cells is far from complete. Where did they come from? The truth is we are still not sure. How they evolved is a problem that still needs to be solved. ●

Eukaryotic cells have many structures not found in prokaryotic cells.



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HISTORY

The History of Pasteurization

BY CAROL WHITE | HowStuffWorks.com | August 31, 2010

There's a fine line between wine and vinegar. That's what Louis Pasteur discovered in 1856 when an alcohol manufacturer commissioned him to determine what was causing beet root alcohol to sour.

At that time, scientists thought that fermentation was a purely chemical process. Pasteur's research into fermentation led him to the discovery that it was yeast, a living organism, that turned the beet juice into alcohol. Under the microscope, yeast was round and plump. But when the alcohol spoiled, it contained a different microbe that was rod-shaped. Pasteur speculated that this rod-shaped microbe called *Mycoderma aceti,* which is commonly used to make vinegar, caused the wine to spoil.

These discoveries formed the "germ" of Pasteur's germ theory of fermentation. Years later, Pasteur would apply the same concepts to the origins of disease, leading to some of his greatest contributions to science and medicine.

In the meantime, Emperor Napoleon III enlisted Pasteur to save France's wine industry from the "diseases of wine." In previous experiments, Pasteur had discovered that heating the fermented wine would kill the microbes that caused it to spoil. He wasn't the first to see that connection. Nicolas Appert, the inventor of in-container sterilization, also known as canning, had already shown that treating food with heat could preserve it. Pasteur's contribution was to determine the exact time and temperature that would kill the harmful microorganisms in the wine without changing its taste. He patented the process and called it pasteurization. Before long, the process was also used for beer and vinegar.

The pasteurization of milk didn't come into practice until the late 1800s. Back then, tuberculosis was commonly carried by milk. A low-temperature, long-time (LTLT) process, also known as batch pasteurization, was first developed to kill the tuberculosis pathogen. The incidence of tuberculosis contracted from milk fell dramatically, and in fact it no longer makes the Centers for Disease Control and Prevention's list of foodborne illnesses.

The first commercial milk pasteurizers were produced in 1882, using a high-temperature, short-time (HTST) process. The first law to require the pasteurization of milk was passed in Chicago in 1908.

Methods of Pasteurization

Batch (or "vat") pasteurization is the simplest and oldest method for pasteurizing milk. Milk is heated to 154.4 degrees Fahrenheit (63 degrees Celsius) in a large container and held at that temperature for 30 minutes. This process can be carried out at home on the stovetop using a large pot or, for small-scale dairies, with steam-heated kettles and fancy temperature control equipment. In batch processing, the milk has to be stirred constantly to make sure that each particle of milk is heated.

High-temperature short-time (HTST) pasteurization, or flash pasteurization, is the most common method these days, especially for higher volume processing. This method is faster and more energy efficient than batch pasteurization. Though the higher temperature may give the milk a slightly cooked flavor, HTST pasteurization has been used for so long that people are used to the flavor.

Louis Pasteur, inventor of the process of pasteurization.

Wikimedia Commons

Louis Pasteur's other Contributions to Science

Louis Pasteur is known as "the father of microbiology." He earned this esteemed title by doing much more than inventing the process of pasteurization. Pasteur's lifetime of discoveries followed a natural arc; each project he worked on led him to his next insight. During his research on tartaric acid in his first job as a scientist, he discovered that organic molecules are asymmetrical. Finding organic molecules in beer and wine led him to recognize that microorganisms such as *Lactobacillus* functioned as the agents of fermentation and food spoilage. This understanding of the role of bacteria helped him to develop his germ theory of fermentation. Years later, he became interested in human disease and applied his knowledge of microorganisms to develop the germ theory of disease. Eventually, he developed the vaccines for chicken cholera, anthrax and rabies. ●

Edited for clarity

MATHEMATICS

Sudoku

#159 PUZZLE NO. 2920805

					4			3
				1				2
8			7	9		2	5	
			2			9		
2		1						
		7			9			4
6	5			2		3	7	9
		2	5				8	

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#160 PUZZLE NO. 6197477

5	3					8		1
	2					6		
				3	7			5
2	4			5	9			
				6		5		
				8			7	
	6			1	4		9	
			8					
		8				2		

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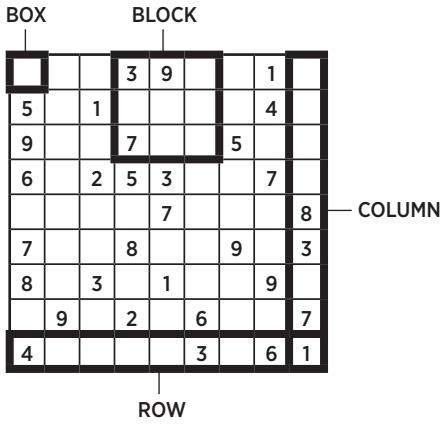
SUDOKU HOW-TO GUIDE

1. Each block, row, and column must contain the numbers 1–9.
2. Sudoku is a game of logic and reasoning, so you should not need to guess.
3. Don't repeat numbers within each block, row, or column.
4. Use the process of elimination to figure out the correct placement of numbers in each box.
5. The answers appear on the last page of this newsletter.



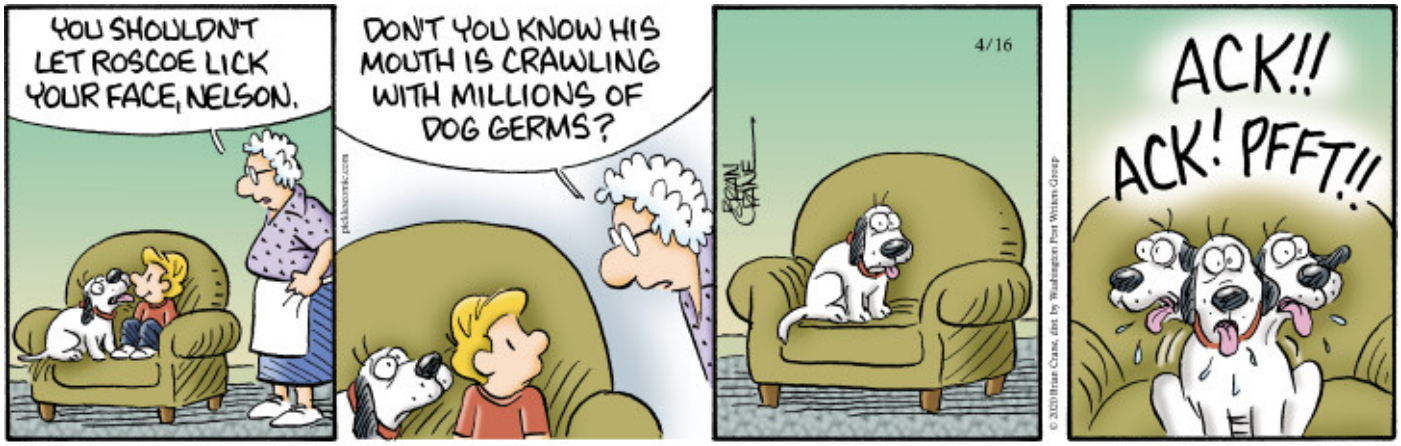
What the example will look like solved

2	4	8	3	9	5	7	1	6
5	7	1	6	2	8	3	4	9
9	3	6	7	4	1	5	8	2
6	8	2	5	3	9	1	7	4
3	5	9	1	7	4	6	2	8
7	1	4	8	6	2	9	5	3
8	6	3	4	1	7	2	9	5
1	9	5	2	8	6	4	3	7
4	2	7	9	5	3	8	6	1

"You live in intimate association with bacteria, and you couldn't survive without them."

BONNIE BASSLER // American molecular biologist

Icons from the Noun Project



Idiom

"Viral marketing"

Meaning Viral marketing is a sales technique that involves organic or word-of-mouth information about a product or service to spread at an ever-increasing rate.

Origin Viral marketing's roots date back to 1996, when a small startup company called Hotline needed a budget-friendly way to promote its new email service, Hotmail. Hotline's team decided to insert the line "Get your own free Hotmail at www.hotmail.com" in all emails. The result? The number of Hotmail users grew from 20,000 to 1 million within a year. By 2001, Hotmail had 30 percent of the email market with 86 million active users. This is an example of one of the most important aspects of viral marketing: every customer involuntarily promotes a service just by using it.

However, it's unclear where the exact phrase originated. In 1996, Jeffrey Rayport, a Harvard Business School professor, authored an article for Fast Company titled "The Virus of Marketing," in which the term "viral marketing" appeared. However, venture capital firm Draper Fisher Jurvetson claims that it coined the term in a 1997 Netscape newsletter, using inspiration from Hotmail's marketing strategy. In 2000, Fast Company published "Unleash Your Ideavirus," an article focusing on the idea economy and how the "ideas that spread the fastest win."

Regardless of its exact origin, there is no doubt that viral marketing could not survive without social networking today. During the 2000s, the major social networks launched. Facebook came to existence in 2000, and YouTube and Twitter launched in 2005 and 2006, respectively.

Source: rivier.edu/academics/blog-posts/history-of-viral-marketing/

DID YOU KNOW?

Bacteria have been on the planet for more than **3.5 billion years**, making them the oldest known life-form.

Bacteria move about **100 times their body length** in a second.

Your body has far more **bacterial cells** than human cells. They help with digestion and defend you from bad bacteria.

In all the world, less than **one percent** of bacteria will make you sick.

Lined up from end to end, bacteria would stretch **10 billion light years**. That's the distance from Earth to the end of the universe.

Different bacteria can survive in a variety of **extreme conditions**. From ice to hot springs, and even radioactive waste.

They weren't discovered until **1674**, when Dutch scientist Antonie van Leeuwenhoek spotted them as he was looking at scrapings from the human mouth under a newly invented microscope.

Source:novatx.com/household-testing/10-fast-facts-bacteria/

ART + CULTURE

Unruly

BY JARI BRADLEY

Hushed whispers in an undisclosed room
Take it out of the girl
a child, boyish in nature their smallness magnified.

Outcasted—the soft bodied animal you are
determined unruly animalia,
what survives inflation & inertia?

The body is a set of complex feedback systems
nothing is as it appears
the coexistence of a beard & breasts
evidence of the body's willfully defiant nature

The body's resilience amid the promise of perish:
somehow the child survives their own hand
the day's weary edge inverted toward grace

A child, boyish in their nature & barrel shaped
survives sedimented against the residue
of dunes, soil, leaf litter, & the bodies of a lesser

What couldn't be excised
your boyish nature
your untamed phylum, your small heart pulsing loud
notes against the night.

WRITING PROMPT
Resilience is a powerful word. It speaks of the strength that comes from adversity and challenge — like the Tardigrade (also known as a Water Bear!) described in the poet's note. Write a poem that describes the ways in which you are resilient — how have you persevered against life's adversity and challenge?

FROM THE POET JARI BRADLEY | "I was inspired by the life cycle of Tardigrades, a phylum of water-dwelling micro animals. They are incredibly resilient, being able to withstand radiation, dehydration, starvation, etc. The unruly nature of its existence reminds me of the black queer child cultivated in a society that seeks to destroy such a child. Writing through abjection has provided another means of staging the resilience of my own body growing up in San Francisco, and the seemingly smallness of such a life."

Word Search

L	S	T	I	C	W	Y	I	H	E	A	R	T	O
S	E	D	G	E	H	Y	R	E	E	C	A	R	G
O	I	R	L	Y	I	D	U	U	G	E	T	E	X
I	E	S	I	X	S	M	U	L	Y	H	P	C	E
L	A	E	U	R	P	I	H	S	L	P	U	N	L
S	N	R	L	E	E	Y	E	U	Y	I	O	E	P
O	Y	E	U	S	R	O	W	R	Y	R	E	I	M
Y	I	R	P	I	S	Y	D	O	B	S	T	L	O
C	X	U	R	D	O	U	L	O	U	D	E	I	C
P	M	T	E	U	L	L	R	I	B	M	R	S	O
X	P	A	S	E	E	I	O	E	W	E	R	E	C
R	H	N	H	W	E	A	R	Y	N	D	I	R	A
G	B	O	Y	I	S	H	N	I	G	H	T	D	A
P	W	E	P	R	O	M	I	S	E	P	I	L	R

WHISPERS
BOYISH
BODY
COMPLEX
RESIDUE
PROMISE
SOIL
EDGE
NIGHT
LOUD
RESILIENCE
GRACE
NATURE
PHYLUM
HEART
WEARY

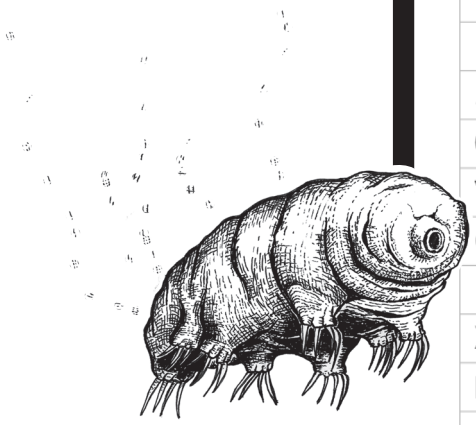


Image by Sandra Haro / iStock

MARINE BIOLOGY

Bacteria at Hydrothermal Vents

WOODS HOLE OCEANOGRAPHIC INSTITUTION | Accessed October 3, 2021

Tiny, single-celled bacteria comprise most life on this planet, yet we have discovered only about five percent of its diversity. We know even less about bacteria thriving at deep-sea hydrothermal vents.

Bacteria at hydrothermal vents inhabit almost everything: rocks, the seafloor, even the inside of animals like mussels. All are living under extreme pressure and temperature changes. Perhaps the oddest and toughest bacteria at vents are the heat-loving 'thermophiles.' Temperatures well above 662°F (350°C) are not uncommon at vents. The "world record" for life growing at high temperatures is 235°F (113¼C), a record held by a type of thermophile known as a hyperthermophile. These thermophiles grow best above 176°F (80°C).

Many thermophiles have a simple diet, based solely on the metals, gases and minerals that comprise the hydrothermal vent fluid. For example, on the research vessel *Knorr,* scientists grew thermophiles collected from vent sites in the Indian Ocean that require only sulfur, hydrogen, and carbon dioxide.

The thermophiles we study today are modern relatives of ancient thermophiles. Think about what types of organisms might have lived more than 3.5 billion years ago. At first, Earth was a hot, volcanically-active planet. Slowly, over the years, it cooled and formed the lands and seas we know today. There are numerous theories that suggest thermophiles—and life — may have originated at deep-sea vents early in Earth's history.

But Earth is not the only place in our solar system where life could evolve and exist. All life as we know it requires water, an energy source and a carbon source. Both Mars and one of Jupiter's moons, Europa, may have these conditions, and thus make good targets to look for past and present life.

Can studying thermophiles at deep-sea vents help us in our search for evidence of past and present life on other planets? Scientists think the answer is yes. Clues on Mars' landscape suggest that water once flowed there. Also, Mars still has an ice cap and there may be liquid water deep in the planet's interior. There is also geologic evidence that Mars once had volcanoes, much larger and more powerful than the volcanoes we know today on Earth. Astrobiologists think that any evidence of life found on other planets will be bacteria-like, living beneath the planet or moon surface and using chemical energy for their life needs.

Thermophiles are also useful to us on a daily basis. Thermophiles make protein molecules called enzymes that speed up chemical reactions. Enzymes from thermophiles are useful in high temperature situations. Enzymes are added to many washing detergents because they can "eat away" the oily stains on clothing in hot water.

Thermophiles may assist in creating terraced rock structures like these, located at Mammoth Hot Springs, Yellowstone National Park, USA. Astrobiologists are interested in how these rocks because it gives them insights into how rocks may form on other planets.

Image from yellowstoneparknet.com

Genetic research is another area where thermophiles are used. The thermophilic DNA enzyme *Taq* polymerase, an enzyme that makes many copies of DNA pieces, was first obtained from the thermophile *Thermus aquaticus* from Yellowstone National Park. This thermophile creates the yellow-mustard color found in many hot springs around Yellowstone's Lower Geyser Basin.

Biotechnology companies have also been selling similar enzymes from deep-sea hydrothermal vent thermophiles. These enzymes are called *Pfu* polymerase and have helped us to discover genetic diseases and sequence the entire human genome.

On this expedition, we use enzymes to try and identify the bacteria we collect from hydrothermal vents. We look for a specific piece of genetic DNA that identifies our organisms, and then we make many copies of the gene. Using this process, we are finding many new types of bacteria at deep-sea vents that we have never seen before. It's amazing to think what we might learn from them. ●

Edited for space

WORD PLAY A Rebus puzzle is a picture representation of a common word or phrase. How the letters/images appear within each box will give you clues to the answer! For example, if you saw the letters "LOOK ULEAP," you could guess that the phrase is "Look before you leap." *Answers are on the last page!*

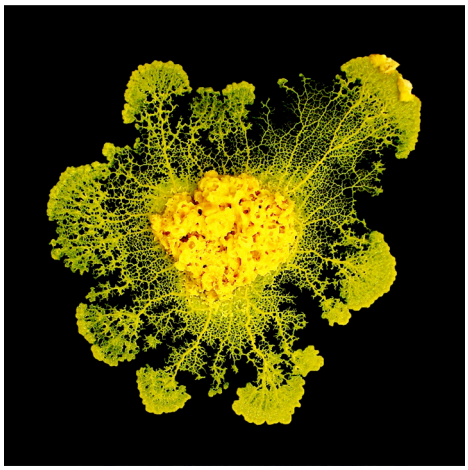
SCIENCE

This Weirdly Smart, Creeping Slime is Redefining Our Understanding of Intelligence

BY MICHELLE STARR | ScienceAlert.com | June 12, 2021

Imagine you're walking into a forest, and you roll over a fallen log with your foot. Fanning out on the underside, there is something moist and yellow — a bit like something you may have sneezed out, if that something was banana-yellow and spread itself out into elegant fractal branches.

What you're looking at is the plasmodium form of *Physarum polycephalum*, the many-headed slime mold. Like other slime molds found in nature, it fills an important ecological role, aiding in the decay of organic matter to recycle it into the food web.



This bizarre little organism doesn't have a brain, or a nervous system — its blobby, bright-yellow body is just one cell. This slime mold species has thrived, more or less unchanged, for a billion years in its damp, decaying habitats.

And, in the last decade, it's been changing how we think about cognition and problem-solving.

"I think it's the same kind of revolution that occurred when people realized that plants could communicate with each other," says biologist Audrey Dussutour of the French National Center for Scientific Research.

"Even these tiny little microbes can learn. It gives you a bit of humility."

P. polycephalum — adorably nicknamed "The Blob" by Dussutour — isn't exactly rare. It can be found in dark, humid, cool environments like the leaf litter on a forest floor. It's also really peculiar; although we call it a 'mold', it is not actually fungus. Nor is it animal or plant, but a member of the protist kingdom — a sort of catch-all group for anything that can't be neatly categorized in the other three kingdoms.

It starts its life as many individual cells, each with a single nucleus. Then, they merge to form the plasmodium, the vegetative life stage in which the organism feeds and grows.

In this form, fanning out in veins to search for food and explore its environment, it's still a single cell, but containing millions or even billions of nuclei swimming in the cytoplasmic fluid confined within the bright-yellow membrane.

Cognition without a brain

Like all organisms, *P. polycephalum* needs to be able to make decisions about its environment. It needs to seek food and avoid danger. It needs to find the ideal conditions for its reproductive cycle. And this is where our little yellow friend gets really interesting. *P. polycephalum* doesn't have a central nervous system. It doesn't even have specialized tissues.

Yet it can solve complex puzzles, like labyrinth mazes, and remember novel substances. The kind of tasks we used to think only animals could perform.

"We're talking about cognition without a brain, obviously, but also without any neurons at all. So the underlying mechanisms, the whole architectural framework of how it deals with information is totally different to the way your brain works," biologist Chris Reid of Macquarie University in Australia tells ScienceAlert.

P. polycephalum is well known to science. Decades ago, it was, as physicist Hans-Günther Döbereiner of the University of Bremen in Germany explains, the "workhorse of cell biology." It was easy to clone, keep, and study.

However, as our genetic analysis toolkits evolved, organisms such as mice or cell lines such as HeLa took over, and *P. polycephalum* fell by the wayside.

In 2000, biologist Toshiyuki Nakagaki of RIKEN in Japan brought the little beastie out of retirement — and not for cell biology. Nakagaki and his team had put a piece of plasmodium at one end of a maze, a food reward (oats, because *P. polycephalum* loves oat bacteria) at the other, and watched what happened.

The results were stunning. This weird little acellular organism managed to find the fastest route through every maze thrown at it.

"That triggered a wave of research into what other kinds of more difficult scenarios we can test the slime mold with," Reid says. "Virtually all of those have been

"Life on earth is such a good story you cannot afford to miss the beginning ... Beneath our superficial differences we are all of us walking communities of bacteria. The world shimmers, a pointillist landscape made of tiny living beings."

LYNN MARGULIS // American theoretical biologist

Image of P. polycephalum

surprising in some way or another, and surprised the researchers in how the slime mold actually performed. It revealed some limitations as well. But mostly, it's been a voyage of revelation on how this simple creature can do tasks that have always been given to and thought to be the domain of higher organisms."

Full of surprises

Nakagaki recreated the Tokyo subway, with the station nodes marked out with oats; *P. polycephalum* recreated it almost exactly — except the slime mold version was more robust to damage, wherein if a link got severed, the rest of the network could carry on.

Yet another team of researchers found that the protist could efficiently solve the traveling salesman problem, an exponentially complex mathematical task that programmers routinely use to test algorithms.

Earlier this year, a team of researchers found that *P. polycephalum* can "remember" where it has previously found food based on the structure of the veins in that area. This followed previous research from Dussutour and her colleagues, who discovered that blobs of slime mold could learn and remember substances that they didn't like, and communicate that information to other blobs of slime mold once they fused.

"I'm still amazed by how, in a way, complex they are because they always surprise you in an experiment, they would never do exactly what you choose to do," Dussutour says.

In one instance, her team was testing a growth medium used for mammal cells, and wanted to see if the slime would like it.

"It *hated* it. It started to build this weird three-dimensional structure so it could go on the lead and escape. And I'm like, 'oh my gosh, this organism'."

A processing network

Although it's technically a single-celled organism, *P. polycephalum* is considered a network, exhibiting collective behavior. Each part of the slime mold is operating independently and sharing information with its neighboring sections, with no centralized processing.

"I guess the analogy would be neurons in a brain," Reid says. "You have this one brain that's composed of lots of neurons — it's the same for the slime mold."

That brain analogy is a really intriguing one, and it wouldn't be the first time *P. polycephalum* has been compared to a network of neurons. The topology and structure of brain networks and slime mold blobs are very similar, and both systems exhibit oscillations.

Defining cognition

As exciting as its escapades may seem, any researcher working with it will tell you that *P. polycephalum* is not, in itself, a brain. It›s not capable of higher-level processing or abstract reasoning, as far as we can tell.

Nor is it, as intriguing as the notion may seem, likely to evolve into something like a brain. The organism has had a billion years to do so and shows no sign of going in that direction (although if any science fiction writers out there like the idea, feel free to run with it).

In terms of overall biology, slime mold is extremely simple. And by that very fact, it's changing how we understand problem-solving.

In a sense, it leaves us with an organism — a wet, slimy, damp-loving blob — whose cognition is fundamentally different from our own. And, just like the Tokyo subway, that can teach us new ways to solve our own problems.

Edited for space and clarity

"It's teaching us about the nature of intelligence, really, challenging certain views, and basically widening the concept," Reid says.

"It does force us to challenge these long-held anthropocentric beliefs that we are unique and capable of so much more than other creatures." ●

RANDOM-NEST

The Domains of Life

BY JESSICA HARWOOD AND DOUGLAS WILKIN | CK12.ORG
Updated November 20, 2019

All of life can be divided into three domains, based on the type of cell of the organism:

1. Bacteria | cells do not contain a nucleus.
2. Archaea | cells do not contain a nucleus; they have a different cell wall from bacteria.
3. Eukarya | cells do contain a nucleus.

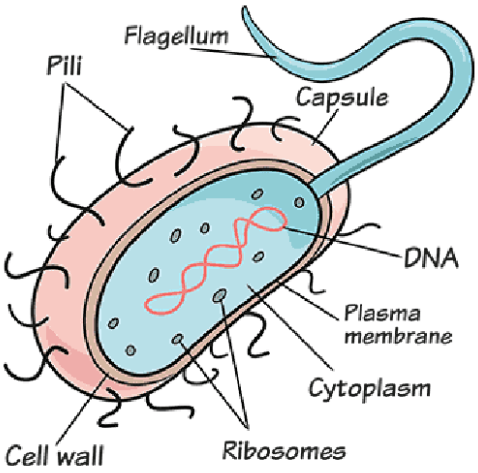
ARCHAEA AND BACTERIA | The Archaea and Bacteria domains are both entirely composed of small, single-celled organisms and seem very similar, but they also have significant differences. Both are composed of cells without a nucleus that reproduce by dividing in two. They also have species with cells surrounded by a cell wall, however, the cell walls are made of different materials. Archaea often live in extreme environments including hot springs, geysers, and salt flats. Bacteria do not live in these environments.

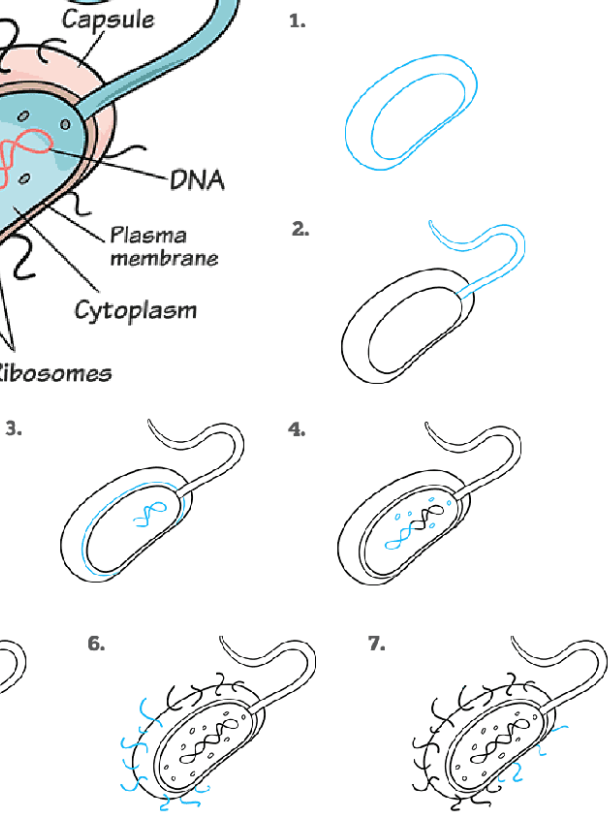
EUKARYA | All of the cells in the domain Eukarya keep their genetic material, or DNA, inside the nucleus. The domain Eukarya is made up of four kingdoms:

1. Plantae | Plants, such as trees and grasses, survive by capturing energy from the sun, a process called photosynthesis.
2. Fungi | Fungi, such as mushrooms and molds, survive by "eating" other organisms or the remains of other organisms. These organisms absorb their nutrients from other organisms.
3. Animalia | Animals also survive by eating other organisms or the remains of other organisms. Animals range from tiny ants to the largest whales, and include arthropods, fish, amphibians, reptiles, and mammals.
4. Protista | Protists are not all descended from a single common ancestor in the way that plants, animals, and fungi are. Protists are all the eukaryotic organisms that do not fit into one of the other three kingdoms. They include many kinds of microscopic one-celled (unicellular) organisms, such as algae and plankton, but also giant seaweeds that can grow to be 200 feet long.

Edited for space

HOW TO DRAW BACTERIA





EasyDrawingGuides.com

WORDS OF ENCOURAGEMENT

While usually only visible under the fine eye of a microscope, microbiomes make up a huge part of our daily lives. From our collective concerns about viruses this past year to new research about emergent types of algae, even the smallest of organisms can prove to take up a large space in our lives. The power of microorganisms reminds us that even the tiniest of things, when working in unison can impart a drastic effect on the world. Even famous microbiologist Louis Pasteur, whose work in germ theory of disease is still utilized to this day, once said, *"Let me tell you the secret that has led me to my goal: my strength lies solely in my tenacity."* Remember that when working toward a goal, we usually must work in these miniscule increments, instead of large leaps. However, this does not mean that we are not making a large impact in our own lives. Always be proud of your own progress not matter seemingly how big or how small. We hope you enjoyed this edition of *The Warbler* this week and wish you all the best in your journey.

Julia

1061 Beard-Eaves Memorial Coliseum // Auburn University, AL 36849

Answers

SUDOKU #159

7	2	9	6	5	4	8	1	3
3	1	8	9	7	2	4	6	5
4	6	5	8	1	3	7	9	2
8	4	3	7	9	6	2	5	1
5	7	6	2	3	1	9	4	8
2	9	1	4	8	5	6	3	7
1	8	7	3	6	9	5	2	4
6	5	4	1	2	8	3	7	9
9	3	2	5	4	7	1	8	6

SUDOKU #160

5	3	7	9	2	6	8	4	1
1	2	9	5	4	8	6	3	7
6	8	4	1	3	7	9	2	5
2	4	1	7	5	9	3	8	6
8	7	3	4	6	2	5	1	9
9	5	6	3	8	1	4	7	2
3	6	5	2	1	4	7	9	8
4	9	2	8	7	5	1	6	3
7	1	8	6	9	3	2	5	4

Rebus Puzzle
Page 7

1. Split the difference
2. He came out of nowhere
3. Wait on hand and foot

Send ideas and comments to:

APAEP
1061 Beard-Eaves
Memorial Coliseum
Auburn University, AL 36849

UNTIL NEXT TIME !